



Figure 1 Mean (\pm s.e.m.) body weight at weaning, age at vaginal opening, and interval between vaginal opening and first vaginal oestrus. Data are for all females combined (a–c) and as a function of intrauterine position (d–f). Body weight at weaning includes data for all females surviving to weaning from control (CON, orange bars) and bisphenol A-exposed (BPA, green bars) litters. All data were adjusted for litter membership to control for maternal effects. Vaginal opening and interval data were also corrected by analysis of covariance for body weight at weaning. 2M, located between two males fetuses; 1M, located next to one male fetus; OM, located next to female fetuses. Wean weight was calculated on 41 OM, 47 1M and 23 2M control females, and 20 OM, 43 1M and 12 2M bisphenol A-treated females. Vaginal opening and interval data were calculated on 19 OM, 20 1M and 19 2M control females, and on 19 OM, 21 1M and 11 2M bisphenol A-treated females. We attempted to include females from each intrauterine position from each litter, but some litters did not contain a 2M female.

to hormones and EEDCs. Our findings indicate that one source of this variability may be the amount of endogenous sex hormones. These vary among individual human fetuses and are influenced by a variety of factors, including whether it is a first pregnancy, the size of the placenta, and whether there is just one fetus or twins^{13,14}.

Very small increases in the level of endogenous oestradiol may substantially increase the sensitivity of fetuses to EEDCs consumed by pregnant women, so some fetuses may be at particularly high risk for a wide array of abnormalities and diseases. Our findings emphasize the need for studies to examine the relationship between maternal exposure to endocrine disrupters and subsequent health effects in the offspring.

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- Colborn, T., vom Saal, F. S. & Soto, A. M. *Environ. Health Perspect.* **101**, 378–384 (1993).
- Gray, L. E. Jr. in *Chemically Induced Alterations in Sexual and Functional Development Vol. 21, The Wildlife/Human Connection* (eds Colborn, T. & Clement, C.) 203–230 (Princeton Scientific, New Jersey, 1992).
- vom Saal, F. S. & Sheehan, D. M. *Forum* **13**, 11–18 (1998).
- Paulozzi, L. J., Erickson, J. D. & Jackson, R. J. *Pediatrics* **100**, 831–834 (1997).
- Herman-Giddens, M. E. *et al. Pediatrics* **99**, 505–512 (1997).
- Dodds, E. C. & Lawson, W. *Nature* **137**, 996 (1936).
- Takao, Y. *et al. J. Health Sci.* **45**, 39 (1999).
- Nagel, S. C. *et al. Environ. Health Perspect.* **105**, 70–76 (1997).
- Even, M. D., Dhar, M. G. & vom Saal, F. S. *J. Reprod. Fertil.* **96**, 709–716 (1992).
- vom Saal, F. S. *J. Anim. Sci.* **67**, 1824–1840 (1989).
- Vandenbergh, J. G. *Endocrinology* **84**, 658–660 (1969).
- vom Saal, F. S., Pryor, S. & Bronson, F. H. *J. Reprod. Fertil.* **62**, 33–37 (1981).
- Panagiotopoulou, K. *et al. Cancer Causes Control* **1**, 119–124 (1990).
- Hsieh, C.-C. *et al. Am. J. Epidemiol.* **136**, 1321–1326 (1992).

Global warming

Solar variability and the Earth's climate

Lockwood *et al.*¹ recently presented some intriguing new evidence of solar variability, but Parker's accompanying News and Views article² gave an exaggerated and misleading picture of the potential effects on terrestrial climate. This picture is at variance with both the evidence³ and a public statement by Lockwood himself, reported in ref. 4.

As Parker mentions, the only available direct measurements show a variation of just 0.15% in solar irradiance *S* over one solar magnetic cycle of 11 years. Greater variations on longer timescales are possible, but other reports^{5,6} give figures that are less than the 0.5% that Parker quotes. Even $\Delta S/S \approx 0.5\%$ implies global mean radiative forcing: $(\Delta S/4)(1 - \alpha) \approx 1 \text{ W m}^{-2}$, where $\alpha \approx 0.3$ is Earth's albedo. For comparison, the Intergovernmental Panel on Climate Change (IPCC) estimates the change in global mean radiative forcing from 1861 to 1990 as 2.0 to 2.8 W m^{-2} from greenhouse gases, -0.2 to -2.3 W m^{-2} from aerosols, and 0.1 to 0.5 W m^{-2} from solar variability^{7,8}. There has been much speculation about additional solar effects but, with regard to Parker's remark about cosmic-ray effects on clouds, we note that the cited work⁹ claims that this effect would only amplify solar radiative forcing to less than 2 W m^{-2} .

We are surprised by Parker's suggestion that solar brightening is responsible not only for the observed increase in twentieth-century surface temperatures, but also for increased carbon dioxide in "the same way that a carbonated drink expels most of its CO_2 if warm". Given the observed surface temperature increase of about 1 K, a simple calculation¹⁰ reveals that this effect would increase equilibrium CO_2 by less than 5%,

which is much less than the 30% increase recorded since the beginning of the industrial revolution. Records of ^{13}C and ^{14}C isotopes relative to ^{12}C also support the idea that changes in atmospheric CO_2 are primarily due to the burning of fossil fuel⁸.

Although solar effects on this century's climate may not be negligible, quantitative considerations imply that they are small relative to the anthropogenic release of greenhouse gases, primarily carbon dioxide. Figure 8.4 of the IPCC 1995 assessment report³ (also shown in refs 7, 11) makes that point clearly, even though it assumes solar variability near the upper end of its uncertainty range⁷.

On longer timescales, it is not a "historical fact" that climate "responds to variations of the Sun's magnetic activity, with substantial warming and cooling with the rise and fall of activity over the centuries". Several recent palaeoclimate compilations^{12,13} indicate only that weak responses to putative solar variations have occurred over the past 500–1,000 years. The data suggest that global mean temperatures during the 1990s may have been the warmest of the millennium. Together with climate model simulations (which, contrary to Parker, quantify the combined effects of cloud, winds, ocean currents, solar effects and anthropogenic effects^{14–16}, however imperfectly), the data indicate that there is probably a strong anthropogenic component to twentieth-century global warming.

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- Lockwood, M., Stammer, R. & Wild, M. N. *Nature* **399**, 437–439 (1999).
- Parker, E. N. *Nature* **399**, 416–417 (1999).
- Santer, B. D. *et al. in Climate Change 1995: The Science of Climate Change* (eds Houghton, J. T. *et al.*) 406–443 (Cambridge Univ. Press, 1996).
- Pearce, F. *New Scientist* p. 5 (5 June 1999).
- Lean, J., Skumanich, A. & White, O. *Geophys. Res. Lett.* **19**, 1591–1594 (1992).
- Hoyt, D. V. & Schatten, K. H. *J. Geophys. Res.* **98**, 18895–18906 (1993).
- Harvey, L. D. D. *et al. An Introduction to Simple Climate Models used in the IPCC Second Assessment Report*, IPCC Technical Paper II (WMO, Geneva, 1997).
- Schimmel, D. *et al. in Climate Change 1995: The Science of Climate Change* (eds Houghton, J. T. *et al.*) 65–139 (Cambridge Univ. Press, 1996).
- Svensmark, H. & Friis-Christensen, E. *J. Atmos. Terrest. Phys.* **59**, 1225–1232 (1997).
- Walker, J. C. G. *Numerical Adventures with Geochemical Cycles* (Oxford Univ. Press, 1991).
- Covey, C. & Hoffert, M. I. *Clim. Change* **37**, 387–390 (1997).
- Mann, M. E. & Bradley, R. S. *Geophys. Res. Lett.* **26**, 759–762 (1999).
- Briffa, K. R. & Osborn, T. J. *Science* **284**, 926–927 (1999).
- Cubasch, U. *et al. Clim. Dynam.* **13**, 757–767 (1997).
- Wigley, T. M. L., Smith, R. L. & Santer, B. D. *Science* **282**, 1676–1679 (1998).
- Tett, S. F. B. *et al. Nature* **399**, 569–572 (1999).